I J R B A T, Issue (XIII) Volume (II) May 2025: 114-120 OPEN ACCESS e-ISSN 2347 – 517X

A Double-Blind Peer Reviewed & Refereed Journal Review Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

 www.ijrbat.in

FARM FORWARD: STRATEGIES TO EQUIP, ELEVATE AND EMPOWER THE LAST-MILE FARMER THROUGH EXTENSION MANAGEMENT

Arnavi A. Nakhate[1], Aditya Sharma[2] and Gouri Reddy [3]

[1] Research Assistant, University of Oxford, arnavinakhate01@gmail.com

[2] Consultant, Development Sector Advisory, Thinkthrough Consulting, Delhi aditya.sharmaa1910@gmail.com

[3] Data Science Student, IIT Madras, gourireddy.yt@gmail.com

Communicated: 29.11.2024 Revision: 17.01.2025 & 30.01.2025 Accepted: 28.02.2025 Published: 31.05.2025

ABSTRACT:

In India, agriculture employs nearly half (45.6%) of the workforce, but the sector contributes only 13.5% to GDP, with smallholder farmers, who constitute 85% of operational holdings, facing persistent poverty and financial vulnerability. Inefficiencies in agricultural extension services contribute to these significant challenges for farmers, including low productivity, financial distress, and vulnerability to climate change and market volatility. This research paper addresses the structural and institutional constraints of India's agricultural extension system, focusing on the manpower deficit, weak linkages between research and field practices, and limited farmer empowerment. Using a data-driven approach informed by stakeholder consultation and secondary datasets from FAO, ICAR, and government sources, this study evaluates both global and Indian models of extension. The analysis identifies three interdependent strategies to address these gaps: (1) digital advisory platforms powered by AI and mobile technologies to provide localized, real-time solutions; (2) strengthening public-private partnerships to scale technologies, integrate markets, and ensure sustainability by leveraging the existing governmental schemes; and (3) farmer-centric approaches including agroecology networks and peer-to-peer digital platforms to foster resilience and self-reliance. Evidence from pilots in India, Sub-Saharan Africa, and Kenya demonstrates substantial improvements in productivity, incomes and resource efficiency. The paper argues that restructured extension services can transform Indian agriculture into a resilient and inclusive system, aligning with national goals such as Viksit Bharat 2047 and the UN Sustainable Development Goals.

Keywords: Agricultural Extension, Digital Platforms, Public-Private Partnerships, Farmer Empowerment, Sustainable Agriculture

INTRODUCTION:

In 2019-20, agriculture employed 45.6% of India's workforce, but contributed only 13.5% to GDP, highlighting a significant employment-to-GDP imbalance. Smallholder farmers, who constitute 85% of India's operational holdings, face persistent financial distress; the average per capita income for agricultural households is INR 10,218 per month, according to the National Statistical Office (NSO). About 53.37% of farm households earn income less than the poverty line. Meanwhile, Smallholder debt, over 52% in 2012-13, has increased in the last decade, while income growth remains below 3% annually. Rising input costs, inflation, and market fluctuations worsen rural poverty and malnutrition.

As per the Food and Agriculture Organization, extension services play a pivotal role in bridging the gap between research and field application. Inefficiencies in agricultural extension management can have disastrous impacts on farmers worldwide. For instance, each year, significant volumes of food are lost after harvest in sub-Saharan Africa (SSA), the value of which is estimated at USD 4 billion for grains alone. Inefficiencies leave farmers vulnerable to climate change, market volatility, and resource constraints. Adopting sustainable land, water, and resource management practices is key to tackling climate change, poverty, and hunger. However, in order to encourage adoption,

http://doi.org/10.29369/ijrbat.2025.010.2.00013

improvements will also be necessary in infrastructure, extension, climate information, access to credit, and social insurance – conditions which are at the heart of rural.

A report by the NITI Aayog highlights how inefficient extension services contribute to this distress since extension services are perhaps the most critical link in raising land productivity through industrial agriculture. Farmers lack timely access to information on crop diversification, sustainable practices, and market linkages, making them vulnerable to cascading financial challenges. Consequently, an estimated 70% of Indian farmers operate under losses, leading to high rates of farmer suicides and rural exodus. These statistics underscore the urgency of addressing inefficiencies in agricultural extension management as a pathway to improving rural livelihoods.

Despite numerous government initiatives including the ATMA, Pradhan Mantri Fasal Bima Yojana, e-NAM, etc India continues to struggle with reaching last-mile farmers effectively. Existing Literature review and case studies emphasize three persistent challenges: (1) Manpower Deficit; (2) Structural Inefficiencies; (3)Farmer Empowerment Deficit.

This study therefore aims to analyze these systemic challenges through a comparative framework, evaluate global models like DigiFarm (Kenya) and WeFarm (Uganda), and propose feasible farmer-centered reforms for India's agricultural extension system.

I. DIGITAL INNOVATION IN AGRICULTURAL EXTENSION

Efficient agricultural extension can transform India by bridging gaps in services, ensuring that vital knowledge, technologies, and sustainable practices reach remote farmers. Through digital innovation, partnerships, and community empowerment, these solutions aim to build an inclusive, resilient agricultural sector. Hence, the policy brief presents three interdependent solutions.

Digital advisory platforms will provide farmers with real-time weather, market, and crop advice, boosting decision-making and productivity. Public-private partnerships will introduce technologies like AI and satellite monitoring, while farmer-centric approaches foster self-reliance, innovation, and collective problem-solving.

Implementing these solutions will boost productivity, farmers' incomes, and resilience while reducing rural poverty, improving nutrition, and advancing gender equity. The goal is to create a self-sustaining agricultural extension network that enhances well-being, food security, and environmental sustainability.

1. Leveraging Digital Advisory Platforms (Apps, SMS, IVR)

Over the past three decades, digital tools, particularly mobile phones, have revolutionized knowledge and market information sharing for farmers. Through these tools, major digital Extension Advisory System initiatives now offer diverse services, including advisory support, market links, financial access, supply-chain management, agricultural intelligence, and bundled platform-based solutions. Digital advisory platforms, utilizing apps, SMS, and IVR (Interactive Voice Response), have the potential to revolutionize agriculture by providing real- time, localized advisory services.

2. AI-driven Personalised Advisory Platforms:

AI-driven personalized advisory platforms use real-time data from satellites, IoT devices, and weather models to deliver tailored recommendations on crop selection, pest control, irrigation, and market prices. These platforms refine insights through machine learning, adapting to local conditions and empowering farmers to optimize resources and boost yields.

Building on this, The World Economic Forum's Centre for the Fourth Industrial Revolution India, in collaboration with the Union Ministry of Agriculture and Telangana, launched the AI4AI initiative. It uses advanced AI technologies to deliver precision-driven insights, enhancing crop management, resource optimization, and market access, with the goal of scaling innovations across India for sustainable agriculture.

http://doi.org/10.29369/ijrbat.2025.010.2.00013

The 18-month pilot spanning three crop cycles saw farmers' net income double to $800 per acre per cycle. Digital advisory services increased chilli yields by 21%, reduced pesticide use by 9% and fertilizer use by 5%, while quality enhancements raised unit prices by 8%. The scheme is currently expanded to 500,000 farmers and has the potential to be extended, if not pan-India, at least to high-yielding and technologically advanced states contributing to increased productivity.

3. Integrating Agri-based Apps:

India has several Agritech Apps for promoting extension services over large-scale farmers such as Kisan Suvidha, mKisan Portal, AgriBazaar and many more. To encourage more farmers to use digital advisory apps, it is important to refer to limited but impactful sources which give a one-stop solution for every aspect of producing the commodity. Hence several services can be integrated with one app to make it comprehensive, and farmer-friendly as well as offer localised customisation.

One such App is DigiFarm, Kenya which acts as a one-stop mobile platform offering comprehensive solutions, from pre- to post-harvest, including financial services, quality inputs, and tailored farming advice. It streamlines information sharing and transactions between agribusinesses and smallholder farmers under an umbrella advisory system.

The estimated improved efficiency in agricultural fields in Kenya accounts for 25%. It has approved around 60,000 digital input loans with 90% repayment rates. Due to its user-friendliness, around 43% of women are currently registered improving overall social capital.

To scale Indian agricultural apps like DigiFarm, they should be customized for regional languages, crops, and conditions. Integrating AI for localized insights and partnering with government schemes like PM-KISAN can boost accessibility. Collaborations with telecom providers for subsidized access and rural internet expansion will enhance reach. Public-private partnerships and digital literacy initiatives can ensure feasibility and sustainability nationwide.

II. PUBLIC-PRIVATE PARTNERSHIP FOR SCALABLE EXTENSION SERVICES

Public-Private Partnerships (PPPs) have proven effective in transforming agricultural extension services by combining public resources with private-sector innovation. In India, initiatives like ITC e-Choupal, eKutir, and DeHaat have improved farmers' access to information, inputs, and markets. For example, ITC e-Choupal has connected over 4 million farmers, reducing costs and increasing productivity by 25%, while eKutir and DeHaat have enhanced incomes by up to 30% through real-time advisory services. However, the reach of these models is limited facing challenges such as structural inefficiencies, lack of policy support, and fragmented execution, which impede the growth and impact of PPPs in agriculture. Despite their potential, India's agricultural extension system still struggles to fully harness these partnerships

- Evidence-Based Model for Agricultural Extension Management

Addressing the shortcomings in India's agricultural extension services demands a robust, evidence-backed model focused on integrating technology, capacity building, and market orientation. The Integrated Agricultural Extension and Innovation Model (IAEIM), proven in Tamil Nadu with trained farmers achieving 40% higher yields, proposes a multi-pronged approach:

1. **Technology-Driven Advisory Systems:** By leveraging the government's advisory system through PPPs, like the e-NAM platform across the country and across the service providers will further benefit the farmers and ease the doing of business. After a set period, ownership is transferred to the government, ensuring long-term sustainability and scalability of agricultural initiatives. While fostering innovation and improving decision-making, Farm-level digital advisory services can enhance productivity by 15%.
2. **Decentralized Resource Centers:** Government schemes such as the National

http://doi.org/10.29369/ijrbat.2025.010.2.00013

Mission on Agricultural Extension and Technology (NMAET) support these centre, with the Build-Operate-Transfer (BOT) model enabling private players to establish and transfer the infrastructure to the government. This allows private partners to set up training hubs, offering farmers education and resources that further can reduce costs by 15%, close knowledge gaps and improve productivity.

3. **Market Integration and Value Addition:** Strengthening direct market linkages through digital marketplaces can boost farm incomes. For example, the eNAM platform has facilitated transactions showcasing the potential of digital market connections to resolve farmer earnings.

The IAEIM addresses the core issues of limited access to resources, fragmented markets, and outdated practices by fostering collaboration among stakeholders. Additionally, it emphasises capacity building through community-based farmer training programs. By adopting such comprehensive models, India can transition towards a more inclusive, efficient, and resilient agricultural extension system.

III. DEVELOPING FARMER-CENTRIC APPROACHES:

Farmer-to-farmer extension is an effective approach which leverages local farmers to address community-specific needs, making it highly suited for farmer-focused outreach. In agricultural extension requires understanding the unique challenges farmers face in different regions. Through participatory methods, extension workers can collaboratively develop technologies and practices tailored to local needs.

India has introduced various farmer-centric initiatives, including participatory technology development and community-based resource management. However, these efforts have largely been researcher-driven, with limited focus on enhancing farmers' learning and decision- making autonomy. But there are some underutilized or untapped strategies that, if effectively adopted, could significantly benefit the agricultural sector. These approaches focus on empowering farmers, fostering innovation, and building resilient farming ecosystems.

1. **Agroecology-based farmer Network**

Agroecology is gaining recognition, but large-scale networks supporting this approach are scarce. Expanding Farmer Producer Organizations (FPOs) can enable smallholders to adopt sustainable practices effectively. It focuses on sustainable farming practices that enhance biodiversity, soil health, and resilience to climate change. Farmer networks practicing agroecology can share knowledge and reduce dependency on chemical inputs, leading to cost savings and environmental sustainability.

Gowing and Palmer (2008) reported a 79% average yield increase from agroecological practices in Sub-Saharan African farming systems. Agroecological practices enhance the resilience of agroecosystems, reducing smallholder farmers' vulnerability to climate change. They lower the risk of crop failure while boosting food security, improving livelihoods, and strengthening community resilience.

Agroecological practices can drive the vision of Viksit Bharat 2047 by fostering sustainable agriculture and enabling the creation of clean and green villages. With active support from panchayats, cooperatives, SHGs, and women SHGs, these initiatives can strengthen rural livelihoods and ensure grassroots-level transformation for a sustainable and prosperous India.

2. **Digital Peer-to-Peer platforms**

India has advanced digital agriculture with platforms like mKisan, Farmers Portal, and M4AGRI, providing farmers with information on government schemes, weather, pest control, and best practices. However, the potential for digital peer-to-peer knowledge-sharing platforms remains largely untapped. The following model used by Kenya is a classic example which allows people to ask questions via SMS and advice/suggestions are catered by their peers.

We Farm is a peer-to-peer (P2P) platform for small-scale farmers, enabling them to ask questions via SMS and receive answers

http://doi.org/10.29369/ijrbat.2025.010.2.00013

from other users, all without internet access. WeFarm's marketplace connects farmers to discounted agricultural and non-agricultural products, like seeds, fertilizers, cooking stoves, and solar systems, helping them expand their operations. It currently serves over 100,000 users in Kenya, Uganda, and Peru, with plans to reach one million farmers within the next year and expand to countries like Tanzania.

Rural India has 425 million smartphone users and has seen a 45% increase in active internet users since 2019. Mobile penetration and expanding FPOs create a strong foundation for peer- to-peer knowledge platforms, which, with government and private support, can transform agricultural extension and address key gaps for farmers.

In conclusion, implementing digital advisory platforms, fostering public-private partnerships, and developing farmer-centric approaches will significantly enhance agricultural extension services in India. These strategies will empower farmers, boost productivity, and improve livelihoods while ensuring sustainability. By focusing on inclusive solutions, India can transform its agricultural sector into a resilient and self-sustaining ecosystem.

CONCLUSION:

India's agricultural sector faces a paradox of high employment but low productivity, a condition aggravated by inefficiencies in extension services, structural imbalances, and farmer vulnerability. This study has demonstrated that the path to reform lies in a triadic approach that integrates digital innovations, public-private partnerships, and farmer-centric models.

Digital platforms especially AI-driven advisories and integrated agritech apps—can provide farmers with localized, real-time solutions. Public–private partnerships, when embedded in evidence-based models, bring scalability, sustainability, and stronger market integration. At the same time, farmer-centric approaches such as agroecology networks and peer-to-peer platforms are critical to fostering resilience, community learning, and sustainable practices.

Together, these approaches can transform agricultural extension into a catalyst for inclusive growth, poverty reduction, and climate resilience. By aligning with Viksit Bharat 2047 and the Sustainable Development Goals, reimagined extension services have the potential not only to uplift farmers' livelihoods but also to establish agriculture as a foundation of India's sustainable future.

REFERENCE:

Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 3: Agriculture and rural development*. FAO Corporate Document Repository. https://www.fao.org/4/t0060e/T0060E03.htm

Sheahan, M., & Barrett, C. B. (2015). Unpacking postharvest losses in Sub-Saharan Africa: A meta-analysis. *World Development, 66,* 49–68. https://doi.org/10.1016/j.worlddev.2014.08.002

Food and Agriculture Organization of the United Nations. (2017). *The future of food and agriculture – Trends and challenges* (p. 44). Open Knowledge Repository. https://openknowledge.fao.org/server/api/core/bitstreams/2e90c833-8e84-46f2-a675-ea2d7afa4e24/content

Food and Agriculture Organization of the United Nations. (2016). *Climate change and food security: Risks and responses*. FAO. https://www.fao.org/3/i5188e/i5188e.pdf

NITI Aayog. (2023, March). *A new paradigm for Indian agriculture: From agroindustry to agroecology*. Government of India. https://www.niti.gov.in/sites/default/files/2023-03/A-New-Paradigm-for-Indian-Agriculture-from-Agroindustry-to-Agroecology.pdf

http://doi.org/10.29369/ijrbat.2025.010.2.00013

Government of India. (2019). *All India report on agricultural census 2015–16*. Ministry of Agriculture and Farmers Welfare, Agriculture Census Division.

Press Information Bureau. (2023). *Average income of farmers* [Press release]. Government of India. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2003180

Ranganathan, T. (2023). *Farmers' income in India: Evidence from secondary data; A study submitted to Ministry of Agriculture*. Institute of Economic Growth. https://iegindia.org/ardl/Farmer_Incomes_Thiagu_Ranganathan.pdf

NITI Aayog. (2023, March). *A new paradigm for Indian agriculture: From agroindustry to agroecology*. NITI Aayog. https://www.niti.gov.in/sites/default/files/2023-03/A-New-Paradigm-for-Indian-Agriculture-from-Agroindustry-to-Agroecology.pdf

Sundaram, N. (2019). Agricultural crisis and farmers suicides in India. *International Journal of Innovative Technology and Exploring Engineering, 8*(11), 1947–1951. https://doi.org/10.35940/ijitee.K1855.0981119

Pye-Smith, C. (2012). *Agricultural extension, a time for change: Linking knowledge to policy and action for food and livelihoods*. Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA).

Food and Agriculture Organization of the United Nations. (2021). *State of food and agriculture 2021: Making agrifood systems more resilient to shocks and stresses*. FAO. https://openknowledge.fao.org/server/api/core/bitstreams/ccaa475b-4c8b-4774-a0d4-aa1c0ba60787/content

World Economic Forum. (2024, January). *How India's AI agriculture boom could inspire the world*. World Economic Forum.Ibid.

CGIAR Platform for Big Data in Agriculture. (n.d.). *Safaricom DigiFarm*. https://bigdata.cgiar.org/digital-intervention/safaricom-digifarm/Ibid.

Indian Council of Agricultural Research. (n.d.). *Public-private partnership in agriculture*. ICAR. https://icar.org.in/sites/default/files/inline-files/Public-Private-Partnership_0.pdf

ITC Limited. (n.d.). *e-Choupal*. ITC Portal. https://www.itcportal.com/businesses/agri-business/e-choupal.aspx

Tamil Nadu Agricultural University. (n.d.). *Working group on agricultural extension*. TNAU. https://agritech.tnau.ac.in/govt_schemes_services/pdf/working%20group-Agri.%20extn.pdf

Brahmachari, K., Mondal, S., Mallick, S., & Chatterjee, A. (n.d.). Impact of public-private partnership in agriculture: A review. *ResearchGate*. https://www.researchgate.net/publication/290059190_Impact_of_public_private_partnership_in_agriculture_A_review#:~:text=The%20limitations%20of%20PPP%20such,working%20mechanism%20and%20policy%20support

Tamil Nadu Agricultural University. (n.d.). *Working group on agricultural extension*. TNAU. https://agritech.tnau.ac.in/govt_schemes_services/pdf/working%20group-Agri.%20extn.pdf

Government of India. (n.d.). *Revised operational guidelines of e-NAM*. Ministry of Agriculture & Farmers Welfare. https://enam.gov.in/web/assest/downl

http://doi.org/10.29369/ijrbat.2025.010.2.00013

oad/Revised-Operational-Guidelines-of-e-NAM.pdf

World Economic Forum. (2022). *Unlock the power of agricultural technology through private-public partnerships*. World Economic Forum. https://www.weforum.org/stories/2022/03/unlock-the-power-of-agricultural-technology-through-private-public-partnerships/Ibid.

Innovative extension strategies for transfer of technologies in potato. *Indian Farming, 74*(5), 43–47. https://epubs.icar.org.in/index.php/IndFarm/article/download/151962/54632/414095

Press Information Bureau. (2024, February 2). *Press release on schemes implemented by the Department of Agriculture and Farmers' Welfare*. Government of India. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2002012

Richardson, M., Coe, R., Descheemaeker, K., Haussmann, B., Wellard, K., Moore, M., et al. (2021). Farmer research networks in principle and practice. *International Journal of Agricultural Sustainability, 20*(3), 247–264. https://doi.org/10.1080/14735903.2021.1930954

Kale, R. B., Gadge, S. S., Durga, P. K., Bhat, R., Khandagale, K., & Mahajan, V. (2024). *Agri-business ecosystem of farmer producer organizations*. National Institute of Agricultural Extension Management (MANAGE) & ICAR-Directorate of Onion and Garlic Research. https://www.manage.gov.in/fpoacademy/reports/Agri-business%20ecosystem%20of%20FPOs.pdf

Gowing, J. W., & Palmer, M. (2008). Sustainable agricultural development in Sub-Saharan Africa: The case for a paradigm shift in land husbandry. *Soil Use and Management, 24*(1), 92–99. https://doi.org/10.1111/j.1475-2743.2007.00137.x

Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development, 35*(3), 869–890.

Press Information Bureau. (2022, August 3). *E-governance*. Ministry of Electronics & IT, Government of India. https://pib.gov.in/Pressreleaseshare.aspx?PRID=1847837

Food and Agriculture Organization of the United Nations. (2017, April 11). *WeFarm: Connecting small farmers without internet*. E-Agriculture. https://www.fao.org/e-agriculture/news/wefarm-connecting-small-farmers-without-internet

Mackay, S. (2019, December 12). *Wefarm – Connecting small-scale farmers to the people and resources they need to be more successful*. Agrilinks. https://agrilinks.org/post/wefarm-connecting-small-scale-farmers-people-and-resources-they-need-be-more-successful

Voice of America. (2017, September 14). *Text message network connects offline farmers in Kenya*. https://www.voanews.com/a/text-message-network-wefarm-connects-offline-farmers-kenya/4029270.html

Gupta, A., & Sachdeva, S. (2023, December 27). *Using smartphones to boost digital literacy among India's rural communities*. World Economic Forum. https://www.weforum.org/stories/2023/12/how-smartphones-can-boost-digital-literacy-among-indias-rural-communities/

http://doi.org/10.29369/ijrbat.2025.010.2.00013